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Environmental Decision Support Methodologies (EDSM)—System Support CY95

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13. ABSTRACT *(Maximum 200 words)*
This report reflects the transition of research and development efforts from the former Battlefield Environmental Effects Modules (BEEM) software to Environmental Decision Support Methodologies (EDSM) and Climate Environment Modules (CLEM), as well as work efforts conducted toward the completion of a number of civil works projects whose implemented concepts have current and future applicability in military environment and terrain applications. It is highly recommended that the reader be familiar with the previous development work, which provides the basis for this effort, by consulting STC-TR's 2502, 2657, 2723, 2721, 2722, 2886, and 2891.

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LIST OF ACRONYMS

ADAR	Airborne Data Acquisition Registration; a digital aerial sensor property of Positive Systems, Inc.
AIS	Aerial Information Systems
ALBE	AirLand Battlefield Environment
AML	Arc Macro Language
ANSI	American National Standards Institute
ARC/Info	GIS software developed and distributed by Environmental Systems Research Institute (ESRI), Inc.
BEEM	Battlefield Environmental Effects Modules
BEES	Battlefield Environmental Effects Software
CEFMS	Corps of Engineers Financial Management System
CIA	Central Intelligence Agency
CLEM	Climate Extraction Module
COTS	Commercial Off The Shelf (usually in reference to software)
DATSAV	A proprietary data format used by NCDC
DCW	Digital Chart of the World
DEM	Digital Elevation Model
DMSV	Digital Multi-Spectral Video
DLG	Digital Line Graph
DoD	Department of Defense
DOQ	Digital Orthogonal Quadrangle
DTED	Digital Terrain Elevated Data
DTSS	Digital Topographic Support System
EDGE	Environmental Design Guidance for Evaluation
ERIM	Environmental Research Institute of Michigan
ESD	Environmental Sciences Division (formerly Environmental Support Branch)
ESRI	Environmental Systems Research Institute
ETI	Environmental Thresholds and Impacts
FLIR	Forward Looking Infra Red
GATF	Government Applications Task Force
GIS	Geographic Information System
GPS	Global Positioning System
GSL	Geographic Sciences Laboratory
GUI	Graphic User Interface
HP	Hewlett Packard
HTML	Hyper Text Markup Language
IDRISI	GIS software developed by Clarke University
Imagine	Image processing software developed and distributed by ERDAS, Inc.
IPC	Low-end SunSPARC station 1
ISMCS	International Station Meteorological Climate Summary
JTNP	Joshua Tree National Park
Landsat (I-IV)	Specific satellite scanner producing panchromatic and/or multispectral imagery
LSU	Louisiana State University
MDEI	Mojave Desert Ecosystem Initiative
NBS	National Biological Service
NCDC	National Climatic Data Center

LIST OF ACRONYMS (Continued)

NCSA	National Center for Supercomputing Applications
NDVI	Normalized Difference Vegetation Index
NPS	National Park Service
NTC	National Training Center, Fort Irwin, California
NTM	National Technical Means
OCR	Optical Character Recognition
OpenWindows	Sun's proprietary X-windows GUI
ORACLE	RDBMS developed and distributed by Oracle Corporation
PC	Personal Computer
PCI	Image processing software developed and distributed by PCI, Inc.
PI	Principal Investigator
PLGR	Precision Lightweight GPS Receiver
POI	Period of Interest
POP3	Post Office Protocol level 3 (POP3)
PostScript	A graphics/text programming/display language
RCW	Red-Cockaded Woodpecker
RDBMS	Relational Data Base Management System
RSTD	Remote Sensing Technology Division (formerly Environmental Sciences Division)
SCIF	Sensitive Compartmented Information Facility
Solaris	Sun's name for its new operating system (UNIX SVR4)
SOW	Statement of Work
SPARC STATION	Any of Sun's 4/X desktop computers
SPOT (I-III)	Système Pour l'Observacion de la Terre–French satellite scanner
SQL	Standard Query Language
STC	Science and Technology Corporation
SunOS	Sun Operating System (a 4.3 BSD UNIX dialect)
TAT	Terrain Analysis Team
TDS	Typical Day System
TEC	U.S. Army Topographic Engineering Center
TNC	The Nature Conservancy
TTL	Topographic Technology Laboratory
USGS	United States Geological Survey
VMP	Vegetation Mapping Project
WMO	World Meteorological Organization
WWD	World WeatherDisc
WWW	World Wide Web
X-windows	Non-proprietary windows programming software

PREFACE

This report was prepared under Contract DACA76-93-D-0005 for the U.S. Army Topographic Engineering Center (TEC), Alexandria, VA 22315-3864 by Science and Technology Corporation, Hampton, VA 23666-1340.

The valuable technical discussions, guidance, and cooperation provided by the following TEC personnel are acknowledged and very much appreciated: Ms. Betty Mandel, Dr. Paul Krause, Mr. Mark Sither, Ms. Joni Jarrett, Mr. Kevin Slocum, Mr. Vinh Duong, Mr. James Staley, Mr. Joseph Watts, Mr. Mark Flood, and Mr. Douglas Caldwell. The Contracting Officer's Representative was Ms. Joni Jarrett.

ENVIRONMENTAL DECISION SUPPORT METHODOLOGIES (EDSM)—SYSTEM SUPPORT CY95

1. INTRODUCTION

This report summarizes the work performed by Science and Technology Corporation (STC) on Contract No. DACA76–93–D–0005, Delivery Order 0002, from 27 December 1994 through 31 December 1996. The initial statement of work (SOW) for this delivery order covered the period 27 December 1994 to 26 December 1995 and is included in Appendix A. Several modifications of the delivery order and the SOW extended the ending date to 31 December 1996. A summary of the modifications performed on the delivery order are listed in Appendix B by courtesy of the Contracting Officer's Representative (COR), Ms. Joni Jarrett. Any modifications to the SOW can be obtained by contacting Ms. Jarrett.

Three significant changes occurred during the period covered by this report. First, the U.S. Army Topographic Engineering Center (TEC) restructured its organization at the laboratory level. The Environmental Sciences Division (ESD), originally under the Geographic Sciences Laboratory (GSL), was renamed the Remote Sensing Technology Division (RSTD) and placed under the newly formed Topographic Technology Laboratory (TTL) when the GSL was abolished. This report will refer in all instances to the RSTD, even though the actual reorganization took place approximately half way through the reporting period. Second, the STC Junior Remote Sensing Analyst working onsite at TEC chose to resign in September 1995 and transfer to a Government position with the RSTD. A replacement was not found until 1 January 1996, when STC hired a Junior Geographic Information System (GIS) Analyst. This change in personnel contributed to a change in focus of the reimbursable work to which STC was assigned. Several modifications to the SOW reflect this fact as well. Finally, it should be noted that duties of the COR were transferred from Mr. Mark Sither to Ms. Joni Jarrett approximately half way through the reporting period.

This report is organized into 13 sections, including this introduction. Each section provides details of the work performed throughout the total period of performance for a specific task. The conclusion is contained in the final section.

2. MOJAVE DESERT TORTOISE HABITAT ASSESSMENT

The Mojave Desert Tortoise Habitat subtask was the primary responsibility of the Junior Remote Sensing Analyst, who was replaced by the Junior GIS Analyst. The main thrust of this task was the integration of various digital imagery and terrain sources and collected field data into a GIS platform to assess the environmental impact of military operations on the Desert Tortoise in the southern Mojave Desert. Much of the work required cooperation with various other Government and private agencies. Because the Desert Tortoise depends on the vegetation available to it for food, part of this task was spent on mapping vegetation in specific areas of the same study site. The vegetation mapping work also served as an introduction to a follow-on task, which was initiated upon completion of the current task. The Principal Investigator (PI) provided software and user support for the classified portion of this project.

The imagery and terrain data collected included four scenes of Digital Terrain Elevation Data (DTED) Level II data, four scenes of Arc Digital Raster Graphics (ADRG) imagery, eight scenes of Landsat Thematic Mapper (TM) imagery, and six scenes of Système Pour l'Observacion de la Terre (SPOT) imagery. The latter included both multispectral scanner (SPOT XS) and panchromatic (SPOT P) types.

In preparation for the 1-week field visit to the study site by the Junior Remote Sensing Analyst, a large number of tasks were undertaken. These included selecting 20 points that were used to collect Global Positioning System (GPS) information, learning the basic operation of a differential GPS unit, preparing two copies of mosaicked aerial photographs of the Mojave study area to determine photo identifiable objects, and retrieving two copies of all maps needed for field work. Four SPOT panchromatic scenes were imported into ERDAS/Imagine and resampled to a 20-m pixel resolution. This was done so that over 50 1:24,000 and 1:40,000 scale maps could be produced and plotted for use during the Mojave field visit.

During the visit to the study site, 32 differentially corrected GPS points over a 3,600 mi^2 area were collected. A vegetation inventory transect of Northern Alvord slopes was conducted as was a Desert Tortoise count in a predetermined area. This count also was videotaped.

A SPOT scene of the study area was imported into ERDAS/Imagine and geographically registered with field-collected raw GPS points. An unsupervised classification of 25 classes for the specific study area was then performed. Three maps of the study area were produced. In addition, SPOT XS and SPOT P scenes were rectified using digital line graphs (DLG). In order to increase spectral resolution and help prove or disprove the use of imagery for this type of activity, a 20-m resolution SPOT XS scene and a 10-m resolution SPOT P scene were merged to produce a 10-m resolution hybrid scene. Apart from the imagery, fully attributed plot boundary coverages and Desert Tortoise sighting coverages were created and integrated into the GIS via the use of Excel spreadsheets and ARC/Info conversion tools.

In an effort to enhance the quality of GIS projects produced, attempts were made to include metadata in the software produced. Metadata are data about data, that is, data describing the data in a project (in this case a GIS). Such descriptions might encompass everything from the data type of an attribute (integer, floating point) to the geoid used in a GIS data layer. To this end, the Junior Remote Sensing Analyst obtained the current set of GIS metadata standards as well as researched the tri-service metadata standards. The results of this research were presented in a 2-day meeting in early August 1995.

STC support for work on integration of imagery for this task was discontinued with the resignation of the Junior Remote Sensing Analyst. This individual continued to support the project in the same capacity as a Government employee. At this time STC's focus on the task via the newly hired Junior GIS Analyst turned to the integration of remaining point, line, and polygon layers into the GIS.

Work by the Junior GIS Analyst on this task was centered on the completion of three of the necessary data bases (geology, soils, and vegetation data) that were included in the final GIS model. Redigitization of the soils coverage was required and performed at TEC. Detailed attributes and feature descriptions were created for the geology and soils data originally digitized at the University of Arizona. Registration of these coverages was completed. Two methods of vegetation data collection were used: belt transect and center pivot. A preliminary vegetation map was produced using the belt transect method. The center pivot vegetation data required reformatting to be conducive to clustering. In cooperation with several Government colleagues, two different data clustering processing methods were examined, using the specialized statistical Commercial-Off-The-Shelf (COTS) software, Statgraphics Plus for Windows 2.0. When the different clustering algorithms were compared using ARC/Info and ERDAS/Imagine, the clustering algorithm weighing the vegetation data by cover was chosen. The data clusters were then integrated into a supervised classification of the spatial and spectral data.

At the same time, methodologies to decrease the postprocessing time of vegetation data for the coming year's field season were studied. Improved methods of vegetation data classification, providing increased statistical robustness and increased applicability as a tool in remote sensing of arid environments, were addressed.

When all the coverages in the GIS were in their final stages, data were collected for every data layer in the GIS using ERDAS/Imagine with the results shown on an Excel spreadsheet. A visual depiction of all the layers was created in ARC/Info, all of which were then exported via an ERDAS/Imagine format into IDRISI. These layers and the spreadsheet were then sent to a project colleague at New Mexico State University who performed a regression tree classification analysis on the data to determine correlations with the tortoise data.

An ARC/Info Arc Macro Language (AML) script was written to produce a quicker image accuracy assessment. The PI cooperated on this portion of the task by writing a small Bourne shell script to reformat the output of the AML into an error matrix. STC personnel (the PI and Junior GIS Analyst) spent several days on part of this task, as an issue arose around the creation of certain ARC/Info grid masks depicting both lines and polygons.

To complete this task the Junior GIS Analyst contributed to the executive summary and final reports for the project. This work included creating a large variety of graphical displays, charts, and maps; writing, editing, and formatting parts of the report; and contributing information for the data dictionary. The final report for this project is titled "FY95 Department of Defer Government Applications Task Force Pilot Project," dated 29 March 1996. This task was completed.

3. FORT IRWIN–JOSHUA TREE NATIONAL PARK VEGETATION MAPPING

The Fort Irwin–Joshua Tree National Park (JTNP) Vegetation Mapping task, which was the primary responsibility of the Junior GIS Analyst, is a follow-on task to the Mojave Desert Tortoise Habitat Assessment task described in Section 2. Although the original intent was to use only Fort Irwin, CA, as the primary study site, JTNP was later included. Working with the Government project manager, the Junior GIS Analyst contributed to developing and reviewing a task list that provided guidance for the project. Much of the work required cooperation with various other Government and private agencies.

The Junior GIS Analyst, the PI, and several Government colleagues met with representatives from Positive Systems. This company was contracted to fly the digital airborne photography necessary to the project. Its proprietary imagery format is called Airborne Data Acquisition Registration (ADAR). A complete morning was spent discussing system and project requirements.

An initial assessment was made in terms of the field trips required to collect field data, what field data would need to be collected, and when the data would be collected. Used in these decisions were sample data sets for JTNP, including five frames of ADAR data flown 2 years ago, Digital Elevation Model (DEM) and DLG data, and two TM scenes of the area. The Junior GIS Analyst produced the field sheets that were to be used for the collection of the field data. It was decided that two trips would be required to collect the necessary field data, with the possibility of one or two short follow-up trips.

During the first trip, work was conducted at the Fort Irwin National Training Center (NTC) for the first 3 days. A circular radius of 10 m was used for each vegetation site surveyed. Every plant within that circle was measured, geolocated, and inventoried. Each circle center geolocated using a GPS unit was marked with a tarp or centered around a photo-identifiable point. In locations of high-density vegetation, only a count of the first six main classes of plants was made. The last 3 days were spent at JTNP using collection methods similar to those at NTC. Upon returning to TEC, the NTC data were entered into Excel spreadsheets with the aid of some macros written by the Junior GIS Analyst. The entered data were then converted to ARC/Info coverages to be used as overlays on the air-flown imagery to be flown during the next reporting period.

Additional preparatory work was performed for the second field trip. Additional locations needed to collect vegetation data were determined through a stratification scheme using aspect, slope, and elevation. Maps of these points, and other pertinent data, were produced to aid in their location while in the field. Work was conducted by the Junior GIS Analyst at JTNP. A total of 108 vegetation plots were surveyed, and a total of 20 tarps were laid down and geolocated using a GPS unit in preparation for the digital imagery collection flight by Positive Systems. The tarps were later removed.

The initial set of raw and registered GPS data for both Fort Irwin and JTNP was received and downloaded to *curly* by the PI. Copies were made of all the data.

After the second field visit, representatives from the National Park Service (NPS), the National Biological Service (NBS), The Nature Conservancy (TNC), Environmental Systems Research Institute (ESRI), Environmental Research Institute of Michigan, the Central Intelligence Agency, Aerial Information Systems (AIS), TEC, and STC (Junior GIS Analyst) met as participants for the Vegetation Mapping Project (VMP). The VMP is a project targeted to comprehensively map the vegetation within the NPS. The TNC is concerned with developing a standard by which all vegetation surveying can be done and a standard system by which to classify or assign vegetation types to the field collected data. The AIS is responsible for photo-interpreting the areas to be mapped, and the ESRI, the project lead, is responsible for mapping the

results of the photo-interpreted, field verified polygons. TEC and STC roles are to use digital image processing techniques to support the mapping of the vegetation for the Malapai Hill quadrangle. The national effort is headed by the NBS. The project is in the prototype phase and the standards to be used are still being reworked. The 2-day meetings were intended to set out the responsibilities of those involved and to project a timeline for the completion of the tasks leading to the final product.

The Junior GIS Analyst processed the field data collected from JTNP by writing several Excel macros to calculate different statistical summaries for each surveyed vegetation plot. These summaries were compared to the original data sheets to discover any errors. In addition, ancillary data, such as GPS coordinates for the plot center, soil, surface geology, and notes, were added to the spreadsheets. The final result will yield a spreadsheet depicting the vegetation species coverage per plot. This information, in turn, will be used to classify and cluster the data into plant series. When all data entries for both sites were completed, the Junior GIS Analyst sent copies of the spreadsheets to participating agencies. Because each agency required its own data format, several Excel macros were written to aid and automate the process. In addition, two ARC/Info point coverages were sent to one agency, depicting the location of the vegetation plots and the ground control point matrix.

One of the basic problems with mapping vegetation is determining the units to be mapped. Polygons can be drawn (with their own set of problems), but labeling the polygons can be more problematic. Because no specialized software was accessible that could be used to "ordinate" the data, reclassification of the data was attempted with the tools then available. Based on previous experimentation, new methods were implemented to process the data more quickly so that several different clustering algorithms could be run in order to find the "best fit" for each of the plots in a vegetative series. Ordinate data obtained from a cooperating agency were used to perform various operations that allow for interpretation of the data. These operations include basic statistics for the various classes assigned according to slope, aspect, elevation, percent cover, and density of plants.

The Junior GIS Analyst was deployed on a 2-day trip to JTNP to observe the processes of identifying, from air photos, physical delineation of vegetative types via varying textures, tones, size of plants, or differences in soil or geology. The intent was that these physical cues would help perform similar operations on the digital data provided by Positive Systems.

With a Government colleague, the Junior GIS Analyst helped identify potential control points on a Landsat TM satellite scene that covers the eastern two-thirds of JTNP. These were passed on to personnel at JTNP who were asked to survey them using a GPS unit. Once the GPS points were returned, the TM scene was manually registered and passed on to JTNP for further processing. It was used in combination with the aerial photography and National Technical Means (NTM) data to determine its utility in desert vegetation mapping on a small scale.

The Junior GIS Analyst devised a method of performing a maximum likelihood classification within the grid module of ARC/Info. This is a semi-automated procedure allowing previously created point and line ARC/Info coverages of field-sampled data to be used as training data to classify both the non-remotely sensed and remotely sensed imagery. The method was chosen over that used in ERDAS/Imagine, which requires the manual entry of all the points being tested.

Statistical data concerning the vegetation communities found at Fort Irwin were compiled. Seven communities were selected as indicative of the study area. Correlations were made between vegetative type and soils, geology, and topographic features. The indicator species within each community were examined as

to soil preferences, slope and aspect preferences, and surficial geologic preferences. These statistics helped to build a predictive model portraying the locations of the communities.

The Junior GIS Analyst continued work on the peer-reviewed journal article concerning the vegetation mapping at Fort Irwin. This involved condensing information included within the final Government Applications Task Force (GATF) report, and adding information about the work conducted in early spring 1996. Also required was the gathering of relevant information from previously published works concerning the subject, as well as the integration of statistical analyses and results described in the preceding paragraph. He also assisted with a paper on the Desert Tortoise that was sent to Ecological Applications for peer review.

The Junior GIS Analyst provided help to a Government member of the Terrain Analysis Team in the compilation of materials for the Mojave Desert Tortoise Modeling World Wide Web (WWW) home page. The opportunity enabled the Junior GIS Analyst to learn some basic Hyper Text Markup Language (HTML) programming by constructing his own home page.

A report received from the NBS/National Park Service VMP was reviewed. The report contained some inaccuracies that were noted and returned.

Many of the coverages necessary for a site map of the JTNP study area were prepared by the Junior GIS Analyst. A contour layer was constructed using a DEM of the study site. Some on-screen digitizing of the roads and trails found on the quad sheet from the ADRG CD of the area was performed. A DLG of the hydrologic features was used. An AML script was written that compiled all of these layers into a single map composition with some annotations added. This site map has already been used in the radiometric calibration report and will be used in the project final report.

The "kick off" meeting for the Mojave Desert Ecosystem Initiative (MDEI)/Mojave Desert Terrain Mapping Team was held at TEC. In attendance at the 2½-day meeting were representatives from the following organizations and locations: Sacramento Corps of Engineers Office, Sacramento, CA; McAuley and Associates, Sedona, AZ; Jones and Stokes Associates, Inc., Sacramento, CA; Louisiana State University, Baton Rouge, LA; and TEC, Alexandria, VA. Details of the project were discussed and decisions were made as to how the project would proceed. The project would follow two basic directions: one effort would use Landsat TM data to derive the mineralogic makeup of the "visible" landforms; a companion effort would use airphotos to delineate "visible" landforms. A hierarchical approach would be used for both approaches. The two approaches would then be joined to produce one final, fully attributed map of the Mojave Desert terrain. The attributes will include mineralogy, rock type, and landform type. This map would be used to aid in the construction of a vegetation map and both would be included in the final product.

One of the vital questions for the project is "Where is the Mojave Desert?" There are several versions of the desert boundaries. The delineation of choice is Bailey's Ecoregions. However, since Mr. Bailey has compiled a number of different versions of the Mojave Desert Ecoregion, the Junior GIS Analyst's role in determining the boundaries was to produce a map showing where two of the ecoregion boundaries fell in relation to roads, cities, and 1:250,000 United States Geological Survey (USGS) topographic quadrangle sheets. The USGS DLGs representing the roads and state boundaries (since the larger of the ecoregion boundaries falls in parts of four states) were compiled. Then an ARC/Info coverage of the 1:250,000 sheet edges was created and locations of the cities in a final map composition were added. The map was taken to a project meeting in California for review. Because the desire to map the entire Mojave Desert ecoregion as outlined by Bailey was not possible with current funding, only the portion of the Bailey

Mojave Desert ecoregion that falls within the state of California was used. The Junior GIS Analyst created the outline that will be used for the boundaries of the study site (unless, upon further review some additional adjustments need to be made). A few other minor adjustments needed to be made to the original Bailey coverage. Not all of JTNP and Death Valley National Park were included in the ecoregion. It had been decided to include both of these parks to help them meet their goals for a complete inventory of their natural resources. Also, the only absolute delimiters of the Mojave Desert, the Garlock Fault, and San Andreas Fault were not used as part of the original Bailey boundary. These adjustments were made and sent to the MDEI data clearing house.

The Junior GIS Analyst revisited the previous year's GATF project: mapping the habitat of the Desert Tortoise. The reason for the return was a poster session and briefing of the project by a Government colleague at the first GATF Poster Session and Conference, which was held at the National Academy of Sciences in Washington, D.C. The Honorable Bruce Babbitt, Secretary of the Interior, and other high ranking officials were in attendance. The maps produced by the Junior GIS Analyst earlier this year were once again used in the briefing. Also created were some of the posters for the poster session that depicted the tortoise statistical habitat evaluation model.

Some transparency materials for future briefings of the Mojave Desert work were produced, both for Fort Irwin and the JTNP. These included all of the map compositions and a few of the site descriptions. A template of the Fort Irwin map compositions was sent to the University of Arizona so that the geostatistics work being conducted at that location could be represented in a format similar to that being produced at TEC. Some of the plant data that was collected for use in the university's geostatistical analysis was delivered.

Raw and processed individual ADAR scenes for both Fort Irwin and the JTNP were received throughout the project period, as were the mosaicked scenes for each location. Preliminary viewing of the imagery revealed a possible problem with the data. To assess the data further, considerable time was spent importing them into ERDAS/Imagine. The data appear to have a "hot spot" in the center of each frame and exhibit bi-directional reflectance, meaning that one side or quadrant is darker than the opposing side or quadrant. These issues were discussed with technicians at Positive Systems, who tried to analyze the situation and offer possible solutions.

During this time, attempts were made by the Junior GIS Analyst to perform some initial processing of the Fort Irwin mosaicked image. Because of the spectral disparity in the individual frames, however, it was determined that additional image processing work might have to be performed on the data in-house. Because Positive Systems could not offer a satisfactory solution to the problem, TEC members researched and found a research article that outlines the formulas and algorithms necessary to perform a correction for bi-directional reflectance. Because the actual procedures for applying the algorithms to the imagery were not included, the paper was studied in order to best implement the corrections on the current data set.

The initial coding of the algorithms for radiometric and bi-directional reflectance correction on the ADAR imagery were written by a Government member of the division using C program code on a Macintosh PowerPC. The PI modified the code slightly to compile on a Sun SPARC STATION. In all, three programs were modified. Although the initial results provided by the corrections were very encouraging, additional work was ongoing at the end of this reporting period to improve the data even further. Once it is considered corrected, the imagery will be returned to Positive Systems to be remosaicked.

The project report deadlines were not met in a timely manner as a result of the problem with the ADAR data. Therefore, the decision was made to move forward and register the original Fort Irwin

mosaicked imagery and attempt to extract the percent vegetative cover to create a cover map of the study site. This cover map can be compared to cover maps created from photo-interpretation, a NTM-derived cover map, and actual field data-derived cover percentages. Assistance was provided by the Junior GIS Analyst in the registration of the mosaic.

This task is not complete in terms of the project it represents. However, since the problems arising out of the ADAR imagery were beyond STC's control, and continued funding has already been established to continue this effort and other related follow-on efforts, the terms of this task are considered to be satisfied to their fullest extent for the current reporting period.

4. WOODPECKER HABITAT ASSESSMENT AND KUDZU VINE GROWTH ASSESSMENT

This task was the primary responsibility of the Junior Remote Sensing Analyst and required the integration of raster imagery and vector files into a spatial model that could assess the environmental impact of military operations on the Red-Cockaded Woodpecker (RCW). Fort Benning, GA, was chosen as the particular site for this study.

As a result of the work being performed at Fort Benning, personnel from the Natural Resources Office inquired whether similar technology could be used to assess the impact of kudzu vine growth, and therefore help their efforts to eradicate this plant. Because the technology was similar, a small work effort was implemented to model kudzu vine.

A third, yet even smaller work effort was put in place in collaboration with research colleagues from the United Kingdom. This effort involved using geostatistics to determine tree-stand variation. In this way, the imagery data collected could serve an additional purpose and increase cost-effectiveness.

To model the RCW habitat, one SPOT scene of Fort Benning was imported into ERDAS/Imagine, along with 31 Digital Multi-Spectral Video (DMSV) scenes. These were used to produce map compositions of the study area. Field data on hardwood longleaf pine, shortleaf pine, and loblolly pine were collected at the study site and were used to spectrally delineate longleaf pine. Longleaf pine is considered the preferred woodpecker habitat. A second set of 54 DMSV scenes were imported (March 1995) from a subsequent scanner acquisition effort. A nondirectional edge detection kernel was applied to these DMSV scenes.

A spatial model was developed that derives RCW habitat from the March DMSV data. Two DMSV scenes were registered and mosaicked. An initial RCW spatial model was tested and refined. Six additional 10,000-ft elevation DMSV scenes were rectified, mosaicked, and incorporated into the model. The RCW spatial model was enhanced to create a vector coverage depicting potential longleaf pine/RCW habitat.

The logic flow of the RCW model was used to create a spatial model for kudzu vine. An AML script was written that enables the elimination of small polygons and rotates unrectified data so that it can be displayed with ERDAS *.img files. An unsupervised classification was performed producing an image with 25 classes. The geographical location of kudzu vine was located and defined spectrally. A map was produced illustrating areas that were defined spectrally as containing kudzu vine and other areas that probably contain kudzu vine.

The Fort Benning image data were archived, compressed, and transferred via File Transfer Protocol (FTP) to the United Kingdom where they were decompressed and unarchived interactively. A combination of a C program and a Bourne shell script was written to rewrite the ASCII representation of a SPOT image into a format acceptable by the geostatistical programs being used by project colleagues in the United Kingdom.

The RCW and kudzu vine spatial models were further refined and their application was demonstrated. A rough draft map of RCW and kudzu vine products were produced for final review. The Junior Remote Sensing Analyst also participated in the review of the Government's final report for this project. Seven final mapping products were produced to illustrate the project.

STC's support of this task ended when the STC Junior Remote Sensing Analyst resigned his position. This task was completed.

5. ARMY ENVIRONMENTAL CENTER GIS-RDBMS INTEGRATION

This task was the primary responsibility of the PI, and required assisting Government personnel in transferring nonspatial, tabular data into a spatial format directly accessible through a GIS via a COTS RDBMS. Most of the work on this task had previously been performed via Delivery Order 0001 (see STC-TR 2886).

The remaining work required importing additional imagery into the software prototype to provide locational background cues. This imagery included one SPOT and one aerial photograph for the Fort Meade study site. These data were imported into ERDAS, rectified, and subsequently exported into the ARC/Info format. In order to implement the transition to the next step of the project, a 90-day demonstration copy of Arcview 2 was installed on *curly*.

Assistance was given in the demonstration of the prototype software developed for this project at TEC during a 2-day technology demonstration sponsored by TEC. Five bug fixes were incorporated into the software before its demonstration.

A demonstration of the Fort Meade Installation Restoration Data Base Management Information System (IRDMIS) was given to a natural resources/GIS manager from Twentynine Palms, CA.

The current ORACLE data base at the time, Release 7.0.16.4, was backed up in preparation for the installation of Release 7.1.4. The upgrade was successfully installed, however, the new release contained an undocumented bug that was resolved within 48 hours with the help of ORACLE technical support.

In order to consolidate and reduce the redundancy in the data being used, a series of small UNIX Bourne shell scripts were written to find matching lines in different data bases.

Assistance was provided in reading American National Standards Institute (ANSI)-labeled nine-track tapes containing DLG and DEMs. Normally these tapes are in an unlabeled format. Two existing UNIX C shell scripts were modified to incorporate choices to read either ANSI-labeled or unlabeled tapes.

The Junior Remote Sensing Analyst contributed to this task by importing 15 Digital Orthogonal Quadrangles (DOQ) in ERDAS/Imagine, for later export to ARC/Info.

STC's support of this task ended when the Government member leading the project transferred to a different division within TEC. This task was completed.

6. OREGON UPPER GRANDE RONDE WATER QUALITY ASSESSMENT

This task was the primary responsibility of the Junior Remote Sensing Analyst and required the integration of various digital imagery sources into a GIS platform to assess the water quality of the Upper Grande Ronde River Basin in Oregon.

The digital imagery used and integrated for this project included Airborne Terrestrial Applications Sensor (ATLAS) data, Forward Looking Infra Red (FLIR) data, Color Infra Red (CIR) imagery, a SPOT scene, and several Landsat TM scenes. All these data were imported and rectified using ERDAS/Imagine. Map compositions were created and plotted using ERDAS/Imagine for the CIR, SPOT, and TM data.

All the imagery was exported to *.lan* format files so that they, in turn, could be imported into ARC/Info grid files and enable coverage overlay and analysis operations.

The PI borrowed eight 4-Mb RAM chips from another division at TEC and installed them on *moe* in preparation for a future on-road demonstration. A 30-day copy of ARC/Info was installed on the same machine. Assistance was provided in the demonstration of the prototype software developed by the RSTD for this project at the Ecological Restoration Symposium held in Chicago, IL, 13–15 March 1995.

Assistance was provided in the demonstration of the same prototype software for this project at TEC during a 2-day technology demonstration sponsored by TEC.

Shortly before his resignation, the Junior Remote Sensing Analyst began planning a field visit for the fall of 1995. As part of the preparation, he developed a methodology for the collection of GPS information including the design of a new precision lightweight GPS receiver (PLGR) data sheet. In mid-September 1995, STC's support of this task was terminated, with the exception of some minor administrative support in terms of setting up data sets on *curly*'s public FTP directory, to be shared by other project partners, as well as creating backup tapes of the project's data.

This task was completed.

7. CLIMATE DATA INTEGRATION

This task was the primary responsibility of the PI, with considerable assistance provided by STC's Senior Computer Scientist. It required the integration of selected climate data stored on the International Station Meteorological Climate Summary (ISMCS) CD into a GIS front end. The extraction of the data was accomplished by modifying the existing code and writing a new C programming code. ARC/Info AMLs were used to construct and display the information retrieved. Two separate ARC/Info algorithms to contour values associated with sparse point data were implemented with considerable success.

After analyzing the coding snippets received from National Climatic Data Center (NCDC) in further detail, it became evident that the storage structure of the data on the ISMCS CD was not available. As a result, a request was made to NCDC via TEC to obtain the complete source code for the ISMCS disk.

After the source code was received, a number of problems became evident. First, the source code contained very few comments and was written in a fashion recognized as "spaghetti code," meaning that the program code was not written in a modular, logical manner that is easily understood by another individual unfamiliar with the code. Second, initial attempts to recompile the code were unsuccessful, due to additional missing code and COTS program libraries the developing agency had neglected to mention or send. Finally, the internal structure used to access the data is extremely complex (spaghetti code notwithstanding). After very serious efforts, the Senior Computer Scientist successfully compiled all the source code and was able to determine the structure for the most common type or format of stations available (five different formats).

The integration of the temperature frequency and discriminant functions was completed. While working with the data it was discovered that a number of monthly precipitation values contain a plus sign in place of the last digit. This has been determined to be an error encoded in the original data set. After discussions between the PI and the Government project leader, the decision was made to ignore these values initially, and later attempt to supplement these values with correct ones from a different table.

In order to supplement the lack of precipitation data in the Foreign Station Climate Summaries located on the ISMCS CD, data from WeatherDisc Associates' World WeatherDisc (WWD) CD were cross-matched with the ISMCS data by World Meteorological Organization (WMO) numbers. Approximately 43 percent of missing ISMCS data were matched exactly by that of the WWD. Precipitation data for the remaining 57 percent of the ISMCS stations will be provided by a spatial matching algorithm to be determined and implemented at a later date. Besides the two shell scripts that accomplished the matching process, a C language program was written to extract the monthly mean, maximum mean, and minimum mean for each station on the WWD. Yearly means also were computed. The data were saved in three separate files to be read by code developed to read the ISMCS data.

Work on a prototype ARC/Info Graphic User Interface (GUI) to access the ISMCS data was completed, and was named Climate Extraction Module (CLEM). A main menu bar has been developed providing access to three input forms allowing different methods of station selection for up to 14 parameters for any 12 months or annual values. It should be noted that a large number of stations will not have data associated with many of the parameters. Access to the analog module and to temperature frequency queries (as an additional parameter) have been provided. Modifications to CLEM were performed after a brief presentation was made to TEC representatives of the Digital Topographic Support System (DTSS). The presentation was intended to collect comments and suggestions on the GUI and the manner in which it accesses information on the ISMCS CD. Requested modifications were noted, and were adhered to (as much as the ARC/Info GUI allowed), based on the human interface design document received from DTSS.

The PI participated in the preparation of products depicting temperature frequency contours prepared from kriging algorithms. He also participated in a brief demonstration of current 6.1 and 6.2 work presented to a number of different TEC division chiefs.

A small shell script was written to allow the import of Adobe Illustrator format files from ARC/Info into CorelDRAW 3.0. This importing will allow easy manipulation of presentation quality images generated by ARC/Info software into a form suitable for transparency-style briefings.

A scanner and optical character recognition software was used to create a computerized text version of an interface design guidelines checklist. These guidelines were followed in the development of the project GUI. This text version was transformed into an HTML document and placed on the TEC GIS WWW home page.

This task was completed.

8. ANALOG CLIMATE MODULE

Previous work in this area—analysis reports, decision methodologies for determining climatic analogies between stations, and previously written code—was gathered, and portions were reviewed to determine how to best integrate it into the current GIS-based implementation (CLEM). These data were also reviewed by the Government project leader for this task. He in turn provided a simple, initial set of "rules" that were implemented and integrated as the Analog Climate Module in CLEM.

This task was completed.

9. TYPICAL DAY GENERATOR

The intent of this task was to develop a methodology to extract climatological data from NCDC DATSAV2 format climate data archives such that a sequential listing of climate parameters and their associated values would be produced, describing a "typical day" for a particular station (climatologically speaking). These data would then be integrated into ongoing battlefield visualization and simulation models currently being developed by other TEC organizations. Incorporating these data would provide a dynamic, more realistic climatic environment during battlefield simulations versus the static climate assumptions currently implemented.

The DATSAV2 format data to be used in the preliminary analysis were transferred from nine-track tape to 8-mm tape in preparation for future access to these data. All nine-track tapes were then manually degaussed and prepared for shipment as excess material. Data files for four stations depicting different climatological profiles were kept on disk and were transferred via FTP to project collaborators in STC Hampton. Using previously written Pascal program code as a guide, C program code was written to read the Control Section and the Mandatory Section from the DATSAV2 data files. Data for an additional station, Kaesong, North Korea, were not available at TEC. These were requested from NCDC, received, downloaded from nine-track tape, and forwarded to Hampton via FTP.

Analysis software previously written to read DATSAV2 variable records was modified to read 1000-byte fixed length records. Some of the earlier data were discovered to have only 6-hourly observation records, versus the usual 3-hourly data. Data for the years 1971 and 1972 are completely missing. Consultations were made with the Government project leader outlining guidelines to follow for extraction of data required for a "typical rainy day" in Kaesong.

The concept was initially evaluated through the use of actual hourly and 3-hourly weather observations, and an artificial event was statistically generated that would mirror the actual average, or typical, event. Both surface-based parameters (e.g., temperature, humidity, and visibility) and upper air elements (cloud height and amount) were statistically generated from the actual weather observations. Although the data were from a single point, the scenario could be representative of a much larger region. The product given to the customer consisted of hourly weather information such as that typically gathered at a weather station during the particular weather event. The first test efforts were concluded with the manual analysis of data from Kaesong for the month of October. These data were used to arrive at typical rain and typical low visibility scenarios for October. In order to gauge the size, complexity, validity, and most useful way to interpret the data, a Senior Scientist at STC's Hampton headquarters analyzed the data using manual and visual methods, while keeping a record of the methods he used to perform the analysis. This analysis, in turn, would provide a basis for an automated extraction routine to be written at a later time, provided interest continued from outside organizations.

An ASCII data table provided by STC Hampton containing the results of the analysis performed on the Kaesong data was reformatted as a Microsoft Excel 5.0 spreadsheet. It was submitted to the Government project leader for review and further discussion.

Evaluation of the results from the first test led to the revision of the method used to prepare the parametric data. The new concept involved the analysis of the desired station's data for a period of interest, usually a 2- or 4-week period. This concept analyzed all observations for that period and a representative actual observation was selected, which satisfied the desired event parameters. A series of rules was developed to group the data into 24-hour days, then sort and evaluate the grouped data and identify those

groups that match the event's definition, e.g., rain showers for two or more continuous observations, or, visibility reduced by fog to less then 1 mile for three continuous observations. A single day was then randomly selected from the pool of available days and a 36-hour period of the actual values for the various parameters was presented to the user as the typical day for that event.

Appendix C contains an overview of the operations of the Typical Day System (TDS). Appendix D contains the 32 rules used by the TDS.

10. ENVIRONMENTAL THRESHOLDS AND IMPACTS STATEMENT STORAGE AND RETRIEVAL

Members belonging to another division at TEC were interested in adapting the work performed on this subtask for their own operational development platform. Brief discussions were held outlining the feasibility of a possible future transfer of technology.

Because of changing project priorities and fiscal concerns, no additional work was performed on this task, other than transferral of the Environmental Thresholds and Impacts (ETI) in their current Paradox data base storage format to the interested division at TEC. Therefore this task is considered complete.

11. WORLDWIDE WEATHER EXTREMES MAPS

Although this task was not one of those outlined in the original Contract Performance Plan for the delivery order, it became one of those to be performed on an as-needed basis. Historically, TEC publishes reports detailing worldwide weather extremes, such as highest recorded temperature, or greatest recorded rainfall. Included in these reports were maps depicting the location of these records. Traditionally, maps for the United States, North America, and the world were included, even though they were costly to print because of their color content.

In an effort to reduce the cost and increase the usefulness of the maps, it was decided to attempt to develop two maps showing U.S. temperature and precipitation records using ARC/Info. The advantage of this method was that the actual location of the weather record could be accurately placed on the map and was easily updatable in a matter of seconds. In addition, virtually limitless hardcopy color copies of the maps could be produced on the division's plotter.

To achieve the desired results, a 1:2,000,000-scale digital coverage of the U.S. from the Arcworld CD was used as the base map. Sample scripts previously written to quickly demonstrate the concept of the task were modified to accommodate the new coverage.

To ingest the original set of data into the GIS, it was entered into a computer, in a minimally formatted fashion, essentially just rows and columns. A *nawk* script, *reformatwedata*, was written that would ingest a file in such a minimally formatted form and reformat it for direct use by the Arc/Info command 'ADD FROM'. This command, in turn, will read the data directly into a predefined Info file. A combination AML and Bourne shell script was written that will read a reformatted weather extremes text file (see above) and create an ARC/Info, plot-ready coverage.

Midway through this effort, the PI began working with a Government colleague, providing guidance and demonstrating step-by-step examples for each of the steps required to complete the first map. Completion of the remaining portions of each map was left to this person. Some of the steps required to finish the maps included the addition of neatlines, neatline tics, neatline labels, legends, and appropriate color schemes.

This task was completed.

12. SYSTEM ADMINISTRATION AND MAINTENANCE

The PI was primarily responsible for the administration and maintenance of the computing hardware and software. Specifically, the computer hardware and software were monitored on a daily basis to prevent or correct problems as they occurred. New hardware and software were researched, ordered, received, verified, and installed.

The major hardware-related tasks are described in the following paragraphs:

A Sun SPARCstation 20, to be named *vulcan,* was ordered, received, and installed. This purchase included a 14-Gb capacity external 8-mm tape drive. Three Human Design System X terminals were ordered and received throughout the reporting period. *Vulcan* was made the boot server for all three. Two of the X terminals served as replacements for existing equipment that was excessed or retained offline for possible future repair; (a Hewlett-Packard (HP) 9000-series computer named *amber* and a Sun SPARCstation IPC named *larry*). The three X terminals were named *spectra*, *amber*, and *larry*. Also purchased was a 200-MHz PowerPC Macintosh Model 9500, with all necessary associated peripherals, including a 4-Gb Small Systems Computer Interface external hard drive. This machine served to replace yet another HP 9000-series computer, named *andrew*, which had been excessed long before. A second 100-MHz PowerPC Macintosh Model 8100, named *schist*, also was incorporated. A number of PC's were added to the division as replacements for older models. These included a Dell Optiplex 75-MHz Pentium, named *ploving*, a Dell Optiplex 133-MHz Pentium named *spock*, a Gateway 2000 166-MHz Pentium named *riker*, and two Gateway 2000 200-MHz PowerPCs named *worf* and *oz*. STC's Sun IPC, *shemp*, was returned to STC corporate headquarters.

Two TTL members were assisted in correctly setting up their SPARCstation 1+ by reconfiguring their Solaris 2.3 operating system and setting up a ½-in magnetic tape drive and a 600-Mb optical rewritable drive. A new internal hard drive was successfully installed and the operating system was moved to it.

A total of three 9-Gb hard drives were received and installed on *curly* and *vulcan*. A 4.3-Gb hard drive was removed from *curly*, and turned over to personnel working on related projects in the Sensitive Compartmented Information Facility. A DesignJet 650C color plotter and a Tektronix Phaser 440 dye-sublimation color printer were received, assembled, installed, and configured. A 1.0-Gb replacement hard drive for *curly* was installed, as was a special serial or parallel card from Magma, Inc. The PI drove to Chantilly, VA, several times to deliver or retrieve HP LaserJet 4 printers with chronic paper-feed roller problems.

The major software-related tasks are described in the following paragraphs:

The PI attended a 1-week course on transitioning from Solaris 1.X to Solaris 2.X. The Junior Remote Sensing Analyst attended a 1-week course at ERDAS, Inc. in Atlanta, GA, titled "Image Analysis and Spatial Modeling."

A Bourne shell script named *sps* was written to be used as a plotter filter to size roll-media plots accurately on a plotter when plotting PostScript files. This script was distributed to other members at TEC.

A Bourne shell script called *catsplit* concatenates up to 676 files produced by the UNIX utility *split*. The script was written to allow the transfer of a very large file in smaller pieces via FTP and then recreate it with ease.

Two Bourne shell scripts, *encode* and *decode*, were written as wrappers to the UNIX utilities *uuencode* and *uudecode*. The scripts were written as a result of the high volume of user requests to learn how to send encoded files via command line e-mail. The original utilities are cryptic to use, even for experienced UNIX users, and the wrappers make the utilities very easy to use.

The ERDAS/Imagine 8.2 was installed on *curly*, along with numerous patches (accessible via FTP) as they became available.

ARC/Info was upgraded twice on *curly* from release 7.0.2 to 7.0.4. Arcview was upgraded from version 2.0b to 2.1.

A National Center for Supercomputing Applications WWW server was installed on *curly* and functionality for counters to track the number of visits per project home page was added. Perl 5.01, a high-level programming and scripting language, was found, downloaded, and compiled. Perl is intended primarily for the manipulation of large text files and is heavily used in writing interactive scripts for WWW home pages. A sample web access statistics Perl script was found on the web and customized for use with *curly's* web server. The most recent versions of the Netscape client browser were downloaded on an as-needed basis.

A Post Office Protocol Level 3 (POP3) server on *curly* was downloaded and installed. This will allow internet e-mail access to Government personnel directly on their PCs. POP3-compatible e-mail clients on PCs are included in the OnNet 2.0 software already in use by Government personnel, as well as by the latest Netscape client software.

Several different geostatistical packages were installed on *vulcan* and *curly* for evaluation purposes.

Comments, suggestions, and material were provided in an advisory capacity to help choose compatible, cost-effective equipment to be used in the design of a demonstration area for the division.

The C-source code for the Sun and Moon algorithms from PCBEEM were extracted and prepared for submittal to another contracting agency.

Twelve (12) different data sets developed using kriging methodology were incorporated into ARC/Info. Contour line coverages representing these data were produced and plotted as map compositions for use in viewgraph presentations.

This task was completed.

13. CONCLUSION

During approximately 2 years that this report covers, STC has provided support to 11 different taskings using a large variety of skills and expertise, including programming, graphics, GIS, remote sensing, system administration, and environmental and climatic data base support. Although some tasks may have slipped from their intended schedule during execution, they were all completed within the time allotted. In the future, STC anticipates continuing to offer and provide its diverse resources in support of the TEC mission.

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APPENDIX A

STATEMENT OF WORK

Delivery Order
Statement of Work
Environmental Decision Support Methodologies (EDSM) - System Support CY95

A. Contractor Tasks:
Environmental Decision Support Methodologies (EDSM) - Systems Support includes technical assistance to development of a next generation spatial environmental information demonstration decision-support system in support of the Army's AirLand Battlefield Environment (ALBE) Thrust Area. Development effort involves continued systems' evolution of a suite of software incorporating Geographic Information System (GIS), Image Processing System (IPS), and Relational Data Base Management System (RDBMS) technologies for use with diverse digital environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and other ancillary data.

Tasks and responsibilities include:

<u>General System Support</u>

General System Support includes technical assistance to: (a) host systems' hardware and software configuration design, development, engineering, test, evaluation, maintenance, and operations' management; and, (b) development of techniques and methodology for identification, collection, validation, storage, integration, analysis, manipulation, query and display of data.

Estimated Level of Effort: Level of effort anticipated necessary for performance of subject tasks and responsibilities is approximately 25 percent of overall delivery order total.

<u>Algorithm Development and Programming Support</u>

Algorithm Development and Programming Support includes design and implementation of a flexible user-friendly, fully integrated package of models, algorithms and routines for soft-copy display and hard-copy output of both textual information and graphic products in support of the decision process. Additional specifications and requirements for Algorithm Development and Programming Support to this delivery order are found in enclosure(s):

1. 'Algorithm Development and Programming Support - DoD/Army Tactical & Non-Tactical Military' dated 18 Nov 94 (3 pages); and,
2. 'Algorithm Development and Programming Support - DoD/Army Non-Tactical Military & Other Federal Government' dated 18 Nov 94 (3 pages).

Estimated Level of Effort: Level of effort anticipated necessary for performance of subject tasks and responsibilities is approximately 75 percent of overall delivery order total.

B. Period of Performance:
The period of performance for this delivery order is for a twelve (12) month period effective on the date of award and terminating twelve (12) months, therefrom.

C. Level of Effort:
It is anticipated that this delivery order will require two (2) contractor employees with appropriate knowledge, skills and abilities for performance of specified tasks and responsibilities. Terms and conditions of this delivery order are designed to provide the minimum level of contractor support essential to accomplishment of designated objectives of the development effort, and at the minimum level of Government funding generally predictable throughout the life of this delivery order and the basic contract.

D. Location of Work:
It is anticipated that the majority of tasks and responsibilities within this delivery order will be performed within the

Topographic Engineering Center or other Government facilities. Additional technical, management and administrative support for this delivery order will be performed in contractor facilities.

E. Security Requirements:
DD Form 254 - 'Contract Security Classification Specification' is applicable to this delivery order. Performance of tasks and responsibilities within this delivery order requires appropriate security clearance up to and including access to TS-SCI. It is anticipated that this delivery order will require two (2) contractor employees with appropriate security clearance, and that all tasks and responsibilities requiring TS-SCI access will be performed solely within the Topographic Engineering Center or other Government facilities. Such security clearances for contractor employees are required not later than six (6) months after award of this delivery order.

F. Sub-Contractors / Consultants:
Sub-Contractors / Consultants are not required for this delivery order.

G. Government-Furnished Property:
Government-Furnished Property (GFP); i.e., support equipment, software, materials, supplies, and MC&G/other data, is not required for this delivery order.

H. Contract Support Property:
Contract support property; i.e., equipment, software, materials, supplies, and MC&G/other data, will be made available for use by contractor within Government facility in performance of specified tasks and responsibilities of this delivery order. Unavailable contract support property will be obtained by the Government through normal procurement channels, subject to limitations in funding or other procurement constraints. If not obtainable by the Government within a reasonable period; i.e., in order to allow timely completion of required delivery order tasks and responsibilities, contractor is authorized to procure appropriate support property subject to constraints of the original cost proposal for delivery order, availability of funds, and approval by the Government. Itemization of specific expenses shall be provided by DD Form 250 - 'Material Inspection & Receiving Report' at time of delivery of support property to Government facilities. All contract support property; i.e., equipment, software, materials, supplies and MC&G / other data, procured by contractor for use by contractor in performance of delivery order tasks and responsibilities shall be transferred to the Government not later than date of submission of final contract deliverables, or upon termination of delivery order, whichever occurs earlier.

I. Contract Performance Plan:
A contract performance plan shall be submitted to the Government not later than sixty (60) days after award date of this delivery order. See DD Form 1423 - 'Contract Data Requirements List:' Data Item No. A001, Title: 'Contract Performance Plan.' Draft contract performance plan will be submitted to the Government for review and evaluation not later than twenty (20) days after award date of delivery order. The Government will require twenty (20) days for review and evaluation of draft. Final contract performance plan is due not later than twenty (20) days after receipt of Government comments. Revised contract performance plans shall be submitted for any extensions of ninety (90) days or more in the delivery order period of performance. Such revised contract performance plans will be due to the Government not later than sixty (60) days after the effective date for any such extension to the delivery order period of performance.

J. Contract End Items:
Contract end items; i.e., contract deliverables, shall be furnished to the Government not later than expiration date of this delivery order. Contract deliverables shall consist of computer software with user interface and internal (on-line) & external (hard copy) documentation. See DD Form 1423 - 'Contract Data Requirements List:' Data Item No. A005, Title: 'Contract Software Product End Items,' Subtitle: 'Software Product / Technical Report.' Contract deliverables shall also include appropriate system demonstration and operations training for Government personnel. Draft contract deliverables will be furnished to the Government for review and evaluation not later than thirty (30) days prior to expiration date of this delivery order. The Government will require fifteen (15) days for review and evaluation of draft deliverables. Final contract deliverables will be due not later than fifteen (15) days after receipt of Government comments. Appropriate distribution statement and other restrictions shall be denoted as necessary. Itemization of specific end items shall be provided on DD Form 250 - 'Material Inspection & Receiving Report' at time of final submission of individual contract deliverables. All

contract support property; i.e., equipment, software, materials, supplies and MC&G / other data, procured by contractor for use with delivery order tasks and responsibilities shall be transferred to the Government not later than date of submission of final contract deliverables, or upon termination of delivery order, whichever occurs earlier.

K. Other Contract Data Requirements:
See DD Form 1423 - 'Contract Data Requirements List:' Data Item No. A002, Title: 'Progress Report (Studies),' Data Item No. A003, Title: 'Performance and Cost Report;' and Data Item No. A004, Title: 'Conference Report'; and other applicable terms and conditions of the basic contract. A delivery order completion notice shall be submitted to the Government not later than thirty (30) days after completion of all designated tasks and responsibilities.

L. Technical Points-of Contact:

1) Contracting Officer's Representative (COR) for this delivery order and basic contract is:

Mark A. Sither	USATEC	Tel: (703) 355-2840
ATTN: CETEC-TD-RE	7701 Telegraph Road	E-Mail: sither@tec.army.mil
	Alexandria, VA 22315-3864	Fax: (703) 355-3176

2) Technical Action Officer for this delivery order is:

Mark A. Sither	USATEC	Tel: (703) 355-2840
ATTN: CETEC-TD-RE	7701 Telegraph Road	E-Mail: sither@tec.army.mil
	Alexandria, VA 22315-3864	Fax: (703) 355-3176

ENCLOSURE 1

Algorithm Development and Programming Support

DoD/Army Tactical & Non-Tactical Military

Battlefield Environmental Effects Modules (BEEM)

Project Overview: Development of applications in support of the Army's AirLand Battlefield Environment (ALBE) Thrust Area and other various DoD/Army programs and initiatives for development and demonstration of techniques and methodology to characterize the natural and induced environments of the battlefield and to perform complex analyses and modeling of the varied impacts of such environments upon military personnel, systems, equipment, and operations. Applications development includes environmental decision support software and products for the testing community, designers and developers, the simulation and modeling community, battlefield commanders, and decision-makers involved with contingency plans for military operations; military training exercises, etc. The Battlefield Environmental Effects Modules (BEEM) development effort focuses upon integration with the ALBE community of geographic information systems (GIS), image processing systems (IPS), and relational data base management systems (RDBMS) technologies in conjunction with various unclassified and classified environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary data; and, for development of techniques and methodologies for data integration, manipulation, statistical analysis, predictive modeling and generation of various textual and graphic products for use in decision-support to the Army's ALBE tactical and various non-tactical military environmental issues, concerns, and activities.

Tasks and Responsibilities: Algorithm development and programming support for CY95 will include development of preliminary techniques and methodology in support of overall system conceptual design and follow-on Battlefield Environmental Effects Modules (BEEM) prototype development. Development effort will take place using various configurations of computer hardware, software, operating systems and peripherals; and diverse DoD/Army, other Federal Government, and commercial sources of environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary data. Initial systems' development will focus upon (a) preliminary investigation into overall system requirements for development of various BEEM software modules; and, (b) development of BEEM decision support-related techniques and methodology. Data, imagery, and related ancillary information employed and software generated will provide a framework for follow-on BEEM environmental decision support techniques' and applications' development.

Specific tasks and responsibilities include:

1. Prototype menu-driven BEEM demonstration decision support software shall be developed; primarily using the 'C' programming language in conjunction with various GIS, IPS and RDBMS software tools, utilities, and associated macro programming language capabilities. An initial 'shell' of a front-end graphical user interface shall be developed for linkage of various individual BEEM software modules which may be developed. Prototype interface will consist of 'push button and pull-down menus' and 'hot-keys' for system operations designed to facilitate subsequent development of integrated systems of various BEEM decision support applications' modules. Initial algorithm development will focus upon creation of techniques for import of various data and related ancillary information into the GIS and RDBMS; e.g., (a) U.S. Naval Oceanographic Command (NOC) 'International Station Meteorological Climate Summary' (ISMCS) textual / statistical data; (b) U.S. Naval Oceanographic Command (NOC) 'Global Upper Air Climatic Atlas' textual / statistical data; (c) U.S. Naval Oceanographic Command (NOC) 'Global Tropical Extratropical Cyclone Climatic Atlas' textual / statistical data; and, (d) U.S. Naval Oceanographic Command (NOC) 'Marine Climatic Atlas of the World' textual / statistical data. Additional techniques shall be developed for analysis, manipulation, query and display of such data and related information; for integration of such data and related information; and, for creation of various textual reports and graphic products for soft-copy display and hard-copy output.

   As necessary, appropriate methodology shall be developed for use of various other environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary data for use within various systems' applications. See listing

of 'Data, Imagery and Related Ancillary Information Source Material for Battlefield Environmental Effects Modules' for current examples of data, imagery, and related ancillary information that might be appropriate for use in BEEM decision support development efforts. Methodology shall be developed using available 'C' programming language and various GIS, IPS and RDBMS software tools, utilities, and macro programming language techniques in performance of required tasks and responsibilities. Techniques and algorithms shall be developed for import of data, imagery, and related information into the GIS, IPS and RDBMS; for analysis, manipulation, query and display of such data, imagery, and related information; for integration of diverse data, imagery, and related information; and, for creation of various textual reports and graphic products for soft-copy display and hard-copy output. As appropriate, portions of existing environmental decision support algorithms and models shall be incorporated into prototype demonstration decision support applications' software.

Future development of various environmental decision support techniques, applications, and models; and, subsequent incorporation of such techniques, applications, and models into an integrated package of BEEM environmental applications' decision support software modules; e.g., a regional environmental scenario module, shall be taken into consideration in software development activities.

Estimated level of effort anticipated for performance of subject tasks and responsibilities is approximately 75 percent of overall total for 'Algorithm Development and Programming Support: DoD/Army Tactical & Non-Tactical Military.'

2. Techniques and algorithms shall be developed for use of DoD/Army 'National Technical Means' (NTM) for use within various systems' applications. Algorithms shall be developed using the 'C' programming language and various GIS and IPS software tools, utilities, and macro programming language techniques for processing of classified NTM into 'derivative product' format for use in classified and unclassified applications. Techniques shall be developed for import of 'derivative' NTM into the GIS and IPS; and, for analysis, manipulation, query and display of such 'derivative' NTM. Initial methodology shall be developed for integration of 'derivative' NTM with other diverse data, imagery, and related ancillary information; and, for creation of various textual reports and graphic products for soft-copy display and hard-copy output. See Section 1 above for additional guidance.

Estimated level of effort anticipated necessary for performance of subject tasks and responsibilities is approximately 20 percent of overall total for 'Algorithm Development and Programming Support: DoD/Army Tactical & Non-Tactical Military.'

3. Follow-on systems' development activities shall be investigated and results furnished by interim report to the Government not later than 60 days prior to end of delivery order period of performance. Such report may be submitted by addendum to monthly technical progress report and shall provide: (a) review and discussion of progress and principal results of overall systems' development progress to date; (b) review and discussion of progress and principal results of current delivery order tasks and responsibilities to date; and, (a) proposed overall system conceptual design outlining recommendations and proposed plan of action for follow-on (1) short-term (<1 Yr.) and, (2) intermediate term (1-5 Yr.) systems' development activities. Proposed systems' development activities, tasks and responsibilities shall be applicable to in-house performance by the Government and/or by external contractor support; and shall be based upon funds and other resources at levels similar to those allocated to this delivery order. Report shall address various issues and concerns related to continued systems' evolution; among which include: (a) data, imagery, and related information; i.e, unclassified and classified digital environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary data; (b) techniques and procedures, to include those related to user interface; i.e., algorithms, routines and models for identification, collection, validation, storage, integration, analysis, manipulation, query and display of data; (c) reports and graphic products appropriate for soft-copy graphical display and hard-copy output; and, (d) host system(s') configuration, maintenance, and operations; e.g., hardware, software, and peripheral equipment; systems' administration and operations' management; repair and maintenance services; etc.

Estimated level of effort anticipated necessary for performance of subject tasks and responsibilities is approximately 5 percent of overall total for 'Algorithm Development and Programming Support: DoD/Army Tactical & Non-Tactical Military.'

Data, Imagery and Related Ancillary Information Source Material for Battlefield Environmental Effects Modules: Current examples of data, imagery and related ancillary information which might be appropriate for use in BEEM decision support development efforts include: Defense Mapping Agency (DMA) 'Digital Chart of the World' (DCW) GIS vector data; Defense Mapping Agency (DMA) 'Arc Digitized Raster Graphics' (ADRG) GIS raster data; Defense Mapping Agency (DMA) 'Interim Terrain Data' (ITD) GIS vector data; Defense Mapping Agency (DMA) 'Digital Terrain Elevation Data' (DTED) GIS raster data; Department of Defense (DOD) 'Defense Meteorological Satellite Program' (DMSP) satellite image data; Department of Defense (DOD) 'National Technical Means' (NTM); National Geophysical Data Center (NGDC) 'Global Ecosystems' Data Bases' textual / statistical data; Carbon Dioxide Information Analysis Center (CDIAC) 'Global Data Bases' textual / statistical data; SPOT Image Corporation 'Système Pour la Observacion de la Terre' (SPOT) satellite image data; National Oceanic and Atmospheric Administration (NOAA) 'Advanced Very High Resolution Radiometer' (AVHRR) satellite image data; National Oceanic and Atmospheric Administration (NOAA) / EOSAT Corporation 'LANDSAT' 'MultiSpectral Sensor' (MSS) satellite image data / 'LANDSAT' 'Thematic Mapper' (TM) satellite image data; U.S. Air Force Environmental Technical Applications' Center (ETAC) 'Surface Observations Climatic Summaries' (SOCS) textual / statistical data; U.S. Army Topographic Engineering Center (TEC) 'Environmental Effects Data Bases' / 'Environmental Threshold & Impacts (ETI) Data Bases' textual / statistical data; U.S. Geological Survey (USGS) 'Digital Elevation Model' (DEM) GIS raster data; U.S. Geological Survey (USGS) 'Digital Line Graph' (DLG) GIS vector data; U.S. Geological Survey (USGS) 'National High Altitude Photography' (NHAP) aerial photography; U.S. Geological Survey (USGS) 'National Aerial Photography Program' (NAPP) aerial photography; U.S. Fish & Wildlife Service (USFWS) National Wetlands Inventory (NWI) GIS vector data; U.S. Naval Oceanographic Command (NOC) 'International Station Meteorological Climate Summary' (ISMCS) textual / statistical data; U.S. Naval Oceanographic Command (NOC) 'Global Upper Air Climatic Atlas' textual / statistical data; U.S. Naval Oceanographic Command (NOC) 'Global Tropical Extratropical Cyclone Climatic Atlas' textual / statistical data; U.S. Naval Oceanographic Command (NOC) 'Marine Climatic Atlas of the World' textual / statistical data; U.S. Soil Conservation Service (SCS) 'Soil Survey Geographic Data Base' (SSURGO) GIS vector data GIS vector data; and, other 'standard' and 'non-standard' project-specific data, imagery and related ancillary information; e.g., Global Positioning System (GPS) remotely-collected point (RCP) data, aerial multispectral / hyperspectral image data, aerial video image data, and data-sparse areas' geostatistically-developed data.

Miscellaneous Information

Project Support-Related Field Work, Conferences, Seminars and Training: As necessary and appropriate, contractor attendance at and/or participation in project support-related field work, conferences, seminars and training is authorized if determined that such activities are necessary to and/or will substantially enhance contractor performance of designated tasks and responsibilities of this delivery order. Requirement and authorization for contractor attendance at and/or participation in such activities in support of designated tasks and responsibilities of 'Algorithm Development and Programming Support: DoD/Army Tactical & Non-Tactical Military' is estimated at one (1) week of effort for one (1) contractor employee. Contractor is authorized reimbursement for necessary expenses ancillary to attendance at and/or participation in such activities; e.g., costs for travel, registration fees, and other miscellaneous expenses.

Other: Additional specifications and requirements for contract deliverables are found in delivery order (a) 'Statement of Work' dated 18 Nov 94; and, (b) DD Form 1423 - 'Contract Data Requirements List' dated 18 Nov 94.

Estimated Level of Effort: Level of effort anticipated necessary for performance of subject tasks and responsibilities for 'Algorithm Development and Programming Support: DoD/Army Tactical & Non-Tactical Military' is approximately 37.5 percent of overall delivery order total.

ENCLOSURE 2

Algorithm Development and Programming Support

DoD/Army Non-Tactical Military & Other Federal Government Civilian

'Dual-Use' Environmental Applications Modules

Project Overview: Development of applications in support of various collaborative interagency DoD/Army & other Federal Government programs and initiatives for development and demonstration of techniques and methodology for 'dual use' applications of defense technologies for peacetime use to detect and correct environmental problems, to manage natural resources, and to sustain the environment; e.g., assistance with environmental impact assessment, surface water quality assessment and monitoring activities, vegetation stress analysis and change detection, etc. The development effort focuses upon integration of geographic information system (GIS), image processing system (IPS), and relational data base management system (RDBMS) technologies in conjunction with various classified and unclassified environmental and topographic data, remotely-sensed imagery, environmental effects information, climatological and meteorological information, related ancillary data; and, for development of techniques and methodologies for data integration, manipulation, statistical analysis, predictive modeling and generation of various textual and graphic products for use in decision-support to 'dual interest' DoD/Army non-tactical military and other Federal Government civilian environmental issues, concerns, and activities. Applications of these developments, techniques and methodologies to the Army's AirLand Battlefield Environments (ALBE) Thrust Area for visualizing the state-of-the-battlefield shall be thoroughly examined and exploited as appropriate.

Tasks and Responsibilities: Algorithm development and programming support for CY95 will include development of preliminary techniques and methodology in support of overall system conceptual design and follow-on 'Dual-Use' Environmental Applications Modules prototype development in conjunction with various on-going collaborative interagency research and development projects. Principal interagency projects for CY95 include: (a) 'Installation Restoration Data Management Information System (IRDMIS) GIS Prototype,' [Army Environmental Center (AEC) Reimbursable Program], (b) 'Surface Water Quality,' [Government Applications' Task Force (GATF)], (c) 'Desert Tortoise Habitat,' [Government Applications' Task Force (GATF)], (d) 'Red-Cockaded Woodpecker Habitat,' [Army Environmental Center (AEC) Legacy Program]; and, (e) 'Applications of Remote Sensing for Resource Management,' [Army Environmental Center (AEC) Legacy Program]. Development effort will take place using various configurations of computer hardware, software, operating systems and peripherals; and diverse DoD/Army, other Federal Government, and commercial sources of environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary data. Initial systems' development will focus upon (a) preliminary investigation into overall system requirements for development of various 'dual-use' environmental applications software modules; and, (b) development of 'dual-use' environmental applications' decision support-related techniques and methodology as dictated by diverse customer requirements. Data, imagery, and related ancillary information employed and software generated will provide a framework for follow-on 'dual-use' environmental decision support techniques' and applications' development.

Specific tasks and responsibilities include:

1. Prototype menu-driven 'dual-use' environmental applications' modules demonstration decision support software shall be developed in support of customer requirements; primarily using the 'C' programming language in conjunction with various GIS, IPS and RDBMS software tools, utilities, and associated macro programming language capabilities. An initial 'shell' of a front-end graphical user interface shall be developed for linkage of various individual 'dual-use' environmental decision support applications' software modules which may be developed. Prototype user interface will consist of various 'push-button,' 'pull-down,' and 'hot-key' menus for system operations designed to facilitate subsequent development of an integrated system of 'dual-use' environmental decision support applications' modules. Initial algorithm development will focus upon creation of techniques for import of diverse environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary information into the GIS, IPS and RDBMS for use within various systems' applications. See listing of 'Data, Imagery and Related Ancillary Information Source Material for 'Dual-Use' Environmental Applications Modules' for current examples of data, imagery, and related ancillary information that might be appropriate for use in 'dual-use' environmental applications' decision

support development efforts. Additional techniques shall be developed for analysis, manipulation, query and display of such data, imagery, and related information; for integration of such data, imagery, and related information; and, for creation of various textual reports and graphic products for soft-copy display and hard-copy output. As appropriate, portions of existing environmental decision support algorithms and models; e.g., the U.S. Geological Survey (USGS) MODFLOW hydrogeologic model, shall be incorporated into individual prototype demonstration decision support applications' software.

As necessary, appropriate methodology shall be developed for use of various other environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary data for use within various systems' applications. See listing of 'Data, Imagery and Related Ancillary Information Source Material for 'Dual-Use' Environmental Applications Modules.' Methodology shall be developed using available 'C' programming language and various GIS, IPS and RDBMS software tools, utilities, and macro programming language techniques in performance of required tasks and responsibilities. Techniques and algorithms shall be developed for import of data, imagery, and related information into the GIS, IPS and RDBMS; for analysis, manipulation, query and display of such data, imagery and related information; for integration of diverse data, imagery, and related information; and, for creation of various textual reports and graphic products for soft-copy display and hard-copy output. As appropriate, portions of existing environmental decision support algorithms and models shall be incorporated into prototype demonstration decision support applications' software.

Future development of various environmental decision support techniques, applications, and models; and, incorporation of such techniques, applications, and models into an integrated package of 'dual-use' environmental applications' decision support software modules shall be taken into consideration in software development activities.

Estimated level of effort anticipated necessary for performance of subject tasks and responsibilities is approximately 75 percent of overall total for 'Algorithm Development and Programming Support: DoD/Army Non-Tactical Military & Other Federal Government Civilian.'

2. Techniques and algorithms shall be developed for use of DoD/Army 'National Technical Means' (NTM) for use within various systems' applications. Algorithms shall be developed using the 'C' programming language and various GIS and IPS software tools, utilities, and macro programming language techniques for processing of classified NTM into 'derivative product' format for use in classified and unclassified applications. Techniques shall be developed for import of 'derivative' NTM into the GIS and IPS; and, for analysis, manipulation, query and display of such 'derivative' NTM. Initial methodology shall be developed for integration of 'derivative' NTM with other diverse data, imagery, and related ancillary information; and, for creation of various textual reports and graphic products for soft-copy display and hard-copy output. See Section 1 above for additional guidance.

   Estimated level of effort anticipated necessary for performance of subject tasks and responsibilities is approximately 20 percent of overall total for 'Algorithm Development and Programming Support: DoD/Army Non-Tactical Military & Other Federal Government Civilian.'

3. Follow-on systems' development activities shall be investigated and results furnished by interim report to the Government not later than 60 days prior to end of delivery order period of performance. Such report may be submitted by addendum to monthly technical progress report and shall provide: (a) review and discussion of progress and principal results of overall systems' development progress to date; (b) review and discussion of progress and principal results of current delivery order tasks and responsibilities to date; and, (c) proposed overall system conceptual design outlining recommendations and proposed plan of action for follow-on (1) short-term (<1 Yr.) and, (2) intermediate term (1-5 Yr.) systems' development activities. Proposed systems' development activities, tasks and responsibilities shall be applicable to in-house performance by the Government and/or by external contractor support; and shall be based upon funds and other resources at levels similar to those allocated to this delivery order. Report shall address various issues and concerns related to continued systems' evolution; among which include: (a) data, imagery, and related information; i.e, unclassified and classified digital environmental and topographic data, remotely-sensed imagery, climatological and meteorological information, and related ancillary data; (b) techniques and procedures, to include those related to user interface; i.e., algorithms, routines and models for identification, collection, validation, storage, integration, analysis, manipulation, query and

display of data; (c) reports and graphic products appropriate for soft-copy graphical display and hard-copy output; and, (d) host system(s)' configuration, maintenance, and operations; e.g., hardware, software, and peripheral equipment; systems' administration and operations' management; repair and maintenance services; etc.

Estimated level of effort anticipated necessary for performance of subject tasks and responsibilities is approximately 5 percent of overall total for 'Algorithm Development and Programming Support: DoD/Army Non-Tactical Military & Other Federal Government Civilian.'

Data, Imagery and Related Ancillary Information Source Material for 'Dual-Use' Environmental Applications Modules: Current examples of data, imagery and related ancillary information which might be appropriate for use in 'dual-use' environmental applications' decision support development efforts include: Defense Mapping Agency (DMA) 'Digital Chart of the World' (DCW) GIS vector data; Defense Mapping Agency (DMA) 'Arc Digitized Raster Graphics' (ADRG) GIS raster data; Defense Mapping Agency (DMA) 'Interim Terrain Data' (ITD) GIS vector data; Defense Mapping Agency (DMA) 'Digital Terrain Elevation Data' (DTED) GIS raster data; Department of Defense (DOD) 'Defense Meteorological Satellite Program' (DMSP) satellite image data; Department of Defense (DOD) 'National Technical Means' (NTM); National Geophysical Data Center (NGDC) 'Global Ecosystems' Data bases' textual / statistical data; Carbon Dioxide Information Analysis Center (CDIAC) 'Global Data bases' textual / statistical data; SPOT Image Corporation 'Système Pour la Observacion de la Terre' (SPOT) satellite image data; National Oceanic and Atmospheric Administration (NOAA) 'Advanced Very High Resolution Radiometer' (AVHRR) satellite image data; National Oceanic and Atmospheric Administration (NOAA) / EOSAT Corporation 'LANDSAT' 'MultiSpectral Sensor' (MSS) satellite image data / 'LANDSAT' 'Thematic Mapper' (TM) satellite image data; U.S. Air Force Environmental Technical Applications' Center (ETAC) 'Surface Observations Climatic Summaries' (SOCS) textual / statistical data; U.S. Army Topographic Engineering Center (TEC) 'Environmental Effects Data Bases' / 'Environmental Threshold & Impacts (ETI) Data Bases' textual / statistical data; U.S. Geological Survey (USGS) 'Digital Elevation Model' (DEM) GIS raster data; U.S. Geological Survey (USGS) 'Digital Line Graph' (DLG) GIS vector data; U.S. Geological Survey (USGS) 'National High Altitude Photography' (NHAP) aerial photography; U.S. Geological Survey (USGS) 'National Aerial Photography Program' (NAPP) aerial photography; U.S. Fish & Wildlife Service (USFWS) National Wetlands Inventory (NWI) GIS vector data; U.S. Naval Oceanographic Command (NOC) 'International Station Meteorological Climate Summary' (ISMCS) textual / statistical data; U.S. Naval Oceanographic Command (NOC) 'Global Upper Air Climatic Atlas' textual / statistical data; U.S. Naval Oceanographic Command (NOC) 'Global Tropical Extratropical Cyclone Climatic Atlas' textual / statistical data; U.S. Naval Oceanographic Command (NOC) 'Marine Climatic Atlas of the World' textual / statistical data; U.S. Soil Conservation Service (SCS) 'Soil Survey Geographic Data Base' (SSURGO) GIS vector data; and, other 'standard' and 'non-standard' project-specific data, imagery and related ancillary information; e.g., Global Positioning System (GPS) remotely-collected point (RCP) data, aerial multispectral / hyperspectral image data, aerial video image data, and data-sparse areas' geostatistically-developed data.

Miscellaneous Information

Project Support-Related Field Work, Conferences, Seminars and Training: As necessary and appropriate, contractor attendance at and/or participation in project support-related field work, conferences, seminars and training is authorized if determined that such activities are necessary to and/or will substantially enhance contractor performance of designated tasks and responsibilities of this delivery order. Requirement and authorization for contractor attendance at and/or participation in such activities in support of designated tasks and responsibilities of 'Algorithm Development and Programming Support: DoD/Army Non-Tactical Military & Other Federal Government Civilian' is estimated at one (1) week of effort for one (1) contractor employee. Contractor is authorized reimbursement for necessary expenses ancillary to attendance at and/or participation in such activities; e.g., costs for travel, registration fees, and other miscellaneous expenses.

Other: Additional specifications and requirements for contract deliverables are found in delivery order (a) 'Statement of Work' dated 18 Nov 94; and, (b) DD Form 1423 - 'Contract Data Requirements List' dated 18 Nov 94.

Estimated Level of Effort: Level of effort anticipated necessary for performance of subject tasks and responsibilities for 'Algorithm Development and

Programming Support: DoD/Army Non-Tactical Military & Other Federal Government Civilian' is approximately 37.5 percent of overall delivery order total.

APPENDIX B

SUMMARY LIST OF MODIFICATIONS TO DELIVERY ORDER #0002

SUMMARY LIST OF MODIFICATIONS TO DELIVERY ORDER #0002

Contract # DACA76-93-D-0005

Indefinite Delivery/Indefinite Quantity Cost plus Fixed Fee Type Contract for 1 year with 4 additional option years
[thru 16 AUG 98]

Base Contract Award: 17 Aug 93
Option Year 1 Exercised: 17 Aug 94 thru 16 Aug 95
Option Year 2 Exercised for Period: 17 Aug 95 thru 16 Aug 96
Option Year 3 " " Sept 96 thru 16 Aug 97

Delivery Order #0002
SF 30 dtd 27 Dec 94
Period: 27 Dec 94 - 26 Dec 95
(initial 12 month period of performance)
Based on SOW: EDSM-SS CY95 dtd 18 Nov 94
& Enclosures 1 & 2:

Algorith Develop....Non-Tactical Military
& " " & Other Fed'l Civ Agencies

Delivery Order #0002 Basic 'K' Mod #P0005
+ (Note: no Mod #'s P0001-P0004)
To exercise Option Year 1
Period: 17 Aug 94 thru 16 Aug 95

Delivery Order #0002 Basic 'K' Mod #P0006

To incorporate DD Form 254

Delivery Order #0002 Mod #0001

SF30 dtd 9 Mar 95

Change total of DO for STC Conf. attendance

Delivery Order #0002 Mod #0002

Additional Contractor Services (CS)

Field Support work & Training class

<Associated with Mod #0006>

Delivery Order #0002 Mod #0003

Additional Contractor Services (CS)

In supplement to EDSM dtd 17 April 95

Delivery Order #0002 Mod #0004

<Administrative>

SF30 dtd 5-9-95 amendment of Mod #0003

Delivery Order #0002 Mod #0005

SF30 dtd 11 May 95

Extend Performance Period

Change End Date from 26 Dec 95 to 31 Dec 95

Delivery Order #0002 Mod #0006

<Incremental Funding; associated with Mod #0002>

SF30 dtd 5-10-95

Delivery Order #0002 Mod #0007

<Add CLIN 0003A>

SF30 dtd 7-28-95

Additional CS & data items

Supplement to EDSM dated 13 June 95

GATF data support

Delivery Order #0002 Mod #0008/0009

<Deobligate funds>

<Incremental funding>

To satisfy funding requirement for next option year

Delivery Order #0002 Basic 'K' Mod #P00007

SF30 dtd 8-14-95

To exercise Option Year 2

Period: 17 Aug 95 thru 16 Aug 96

Deobligated & Reobligated funds to satisfy # rqmt.

Delivery Order #0002 Mod #0010

SF30 dtd 9-20-95; awarded 20 Sept 95

Additional CS

Fort Irwin project support

Extend Performance Period

Change End Date from 27 Dec 95 to 30 Oct 96

Delivery Order #0002 Mod #0011

SF30 dtd 2-21-96

<Additional work; incremental funding>

<Extend Performance Period>

1 Jan 96 thru 31 Dec 96

Four Task SOW

Delivery Order #0002 Mod #0012

Awarded 17 April 96

<Incremental funding>

Delivery Order #0002 Mod #0013

SF30 dated 8 May 96

<Correct incorrectly added estimated cost on Mod #0011>

<Additional work for Irwin data collect;

associated with Mod #0010>

Performance Period thru 30 Oct 96

Delivery Order #0002. Mod #0014/P00008

SF30 dated 22 July 96

Modified Basic 'K' to allow funding to exercise Option Year 3

Based on reducing max contract amount [for option year]

Effective SF 30 dated 8 July 96

Change paying office from Ohio to TEC

P00009

SF30 dated 1 Aug 96

Extend Option Year 2 from 16 Aug to 6 Sept 96

Allowance for new CEFMS processing

Delivery Order #0002 Mod #0015/P00010

SF30 dated 4 Sept 96

Exercise Option Year 3

Incremental funding applied towards Mod #0011

Delivery Order #0002 Mod #0016

SF30 dated 19 Sept 96

Incremental funding applied towards Mod #0011

APPENDIX C

TYPICAL DAY SYSTEM OPERATIONS OVERVIEW

USER ACTIONS

Using the following tables, the user selects a location and Period of Interest (POI) by entering the corresponding numbers into the Typical Day entry screen.

1. Choose one location from available sites

	LOCATION		LOCATION		LOCATION
1	Kaesong, North Korea	4	Kunsan, South Korea	7	Fort Drum, New York
2	Daggett, California	5	Managugua, NK		
3	Fort Hood, Texas	6	Eielson Air Force Base, Alaska		

2. Choose a Period of Interest (POI)

1	January	13	1-15 January	25	16-31 January
2	February	14	1-15 February	26	16-29 February
3	March	15	1-15 March	27	16-31 March
4	April	16	1-15 April	28	16-30 April
5	May	17	1-15 May	29	16-31 May
6	June	18	1-15 June	30	16-30 June
7	July	19	1-15 July	31	16-31 July
8	August	20	1-15 August	32	16-31 August
9	September	21	1-15 September	33	16-30 September
10	October	22	1-15 October	34	16-31 October
11	November	23	1-15 November	35	16-30 November
12	December	24	1-15 December	36	16-31 December

The Typical Day System (TDS) will then process the date for the selected location and POI and provide the user a list of frequency of occurrences for the following list of weather conditions. The user will then choose a weather condition based on the TDS provided frequency of occurrence.

3. Choose one weather condition for use in preparing a typical day

SKY CONDITIONS		PRECIPITATION		TEMPERATURE	
1	Clear	6	Rain/rain showers	10	Very Hot
2	Cloudy	7	Snow/snow showers	11	Hot
3	Low Ceiling	8	Thunderstorms	12	Cold
4	Very Low Ceiling	9	Freezing Precipitation	13	Severe Cold
5	Extremely Low Ceiling	PERIODS		14	Above Average
RESTRICTED VISIBILITY		20	Fog	15	Average
17	Low Visibility	21	Rain	15	Below Average
18	Very Low Visibility	22	Snow		
19	Extremely Low Visibility	23	Wind		
COMBINATIONS					
24	Low Ceilings & Rain	27	Very Low Visibility & Rain	30	Low Ceilings, Very Low Visibility & Rain
25	Low Ceilings & Snow	28	Very Low Visibility & Snow	31	Low Ceilings, Very Low Visibility & Snow
26	Low Ceilings & Fog	29	Very Low Visibility & Fog	32	Low Ceilings, Very Low Visibility & Fog

The following actions summarize the steps taken by the TDS software to produce a single typical day scenario

TDS ACTIONS

1. Identify records for the location and POI based on user inputs
2. Assign consecutive numbers to each record
3. Compute frequency of occurrence for each climatic condition
4. Display the frequencies in a numbered list to the user
5. Group records by day where each record in a group has the same day, month, year, set group = **ddmmyy**
6. Based on input from the user select the appropriate rule **(see Weather Rules file)** to satisfy the selected weather condition and develop list "**goodx**"
7. Randomly select one group from list "**goodx**"
8. Add +/- 6 consecutive observations to selected group
9. Display "plused-up" group of parameters by hour to user using the sample display that follows

SAMPLE DISPLAY

Typical Day: 15 December 1934 (Show date for selected day)

Valid Period of Display: 141800Z to 160500Z

Hour (GMT)	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11
Sky Condition	A																	
Visibility (miles)	B																	
Present Weather	C																	
Wind Direct (deg)	D																	
Wind Speed(mph)	E																	
Temperature (F)	F																	
Dew Point (F)	G																	
Precip (Inches)	H																	
Past Weather	I																	

Hour (GMT)	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05
Sky Condition	A																	
Visibility (miles)	B																	
Present Weather	C																	
Wind Direct (deg)	D																	
Wind Speed(mph)	E																	
Temperature (F)	F																	
Dew Point (F)	G																	
Precip (Inches)	H																	
Past Weather	I																	

Legend:

Letter	Use M Cell	M Cell Values	M Cell Units	Display in this Format
A	M04 and M06	0-999	M04-meters M06-numbers	"X amount" e.g., 2 Sctd 15 Brkn 100 Ovcst. X values in humdres of feet. Need to convert M04 values to feet and M06 values to sctd, etc.
B	M12	0000-9999	meters	"X.X" miles. Need to convert M12 values to miles.
C	M14	00-99	numbers	"Words". Need to use WMO Code 4677 to convert from numbers to words.
D	M01	000-999	degrees	"XXX" degrees. Need to convert some numbers to calm, missing, variable, report others (001-360) as is.
E	M02	0000-9999	tenths of meters	"X" miles per hour. Need to convert to mph and words like calm and missing.
F	M21	0000-9999	tenths of degree Kelvin	"X" F. Need to convert M21 to degrees F.
G	M22	0000-9999	tenths of degree Kelvin	"X" F. Need to convert M21 to degrees F.
H	AARRR	00000-99999	tenths of millimeters	"X" inches. Need to convert values to inches and words like trace and missing.
I	M19	00-99		"Words". Use WMO Code 4561 to convert to words.

APPENDIX D

WEATHER RULES

SKY CONDITION - CLEAR(1)

Definition Sky is reported either clear or scattered more then 50 percent of the observations during a 24 hour day

For each group **ddmmyy**,

count number of records,

set = **d**

count number of records

if M06 = 00 OR 02,

set = **R**

if **R** >= **0.5d**,

then,

put **ddmmyy** in list **good1**

Repeat as needed for the next group

SKY CONDITION - CLOUDY (2)

Definition Sky is reported broken, overcast, partially obscured, or obscured for more then 50 percent of the observations during a 24 hour day and the lowest ceiling is <= 5000 feet.

For each group **ddmmyy**,

count number of records,

set = **d**

count number of records

if M06 = 07, 08, 09, or 10

and

M04 <= 56 or >= 90 and <= 96,

set = **R**

if **R** >= **0.5d**,

then,

list **ddmmyy** in list **good2**

Repeat as needed for the next group

SKY CONDITION - LOW CEILING (3)

Definition Sky is reported broken, overcast, partially obscured, or obscured for more then 50 percent of the observations during a 24 hour day and the lowest ceiling is <= 3000 feet.

For each group **ddmmyy**,

count number of records,

set = **d**

count number of records

if M06 = 07, 08, 09, or 10

<u>and</u>

M04 <= 33 or >= 90 and <= 95,

set = **R**

if **R** >= **0.5d**,

then,

put **ddmmyy** in list **good3**

Repeat as needed for the next group

SKY CONDITION - VERY LOW CEILING (4)

Definition: Sky is reported broken, overcast, partially obscured, or obscured for more then 50 percent of the observations for a 24 hour day and the lowest ceiling is <= 1000 feet.

For each group **ddmmyy**,

count number of records,

set = **d**

count number of records

if M06 = 07, 08, 09, or 10

<u>and</u>

M04 <= 11 or >= 90 and <= 93,

set = **R**

if **R** >= **0.5d**,

then,

put **ddmmyy** in list **good4**

Repeat as needed for the next group

SKY CONDITION - EXTREMELY LOW CEILING (5)

Definition Sky is reported broken, overcast, partially obscured, or obscured for more then 50 percent of the observations for a 24 hour day and the lowest ceiling is <= 500 feet.

For each group **ddmmyy**,

count number of records,

set = **d**

count number of records

if M06 = 07, 08, 09, or 10

<u>and</u>

M04 <= 06 or >= 90 and <= 92,

set = **R**

if **R** >= **0.5d**,

then,

put **ddmmyy** in list **good5**

Repeat as needed for the next group

PRECIPITATION - RAIN/RAIN SHOWERS (6)

Definition: Includes any type of liquid precipitation, including thunderstorms and rainshowers, that is not reported as freezing. Includes cases where some type of precipitation was reported, either at the time of the observation or within the past hour. Includes at least two occurrences in a day.

For each group **ddmmyy**,

count number of records

if M14 = 10 or 14 or 15 or 20 or 21 or 25 or 29 or 50-56 or 60-65 or 80-82 or 91 or 92 or 95-99

OR

M19 = 4-6 or 8 or 9,

set = **R**

if **R** >2,

then,

put **ddmmyy** in list **good6**

Repeat as needed for the next group

PRECIPITATION - SNOW/SNOW SHOWERS (7)

Definition: Includes any type of solid precipitation, including snow showers, that is reported as freezing. Includes cases where some type of frozen precipitation was reported, either at the time of the observation or within the past hour. Includes at least two occurrences in a day.

For each group **ddmmyy**,

count number of records

if M14 = 22 or 23 or 25 or 70-79 or 83-90 or 93 or 94

OR

M19 = 7 or 8,

set = **R**

if **R > 2**,

then,

put **ddmmyy** in list **good7**

Repeat as needed for the next group

PRECIPITATION - THUNDERSTORMS (8)

Definition: Includes any type of thunderstorms. Includes cases where thunderstorm was reported, either at the time of the observation or within the past hour. Includes at least two occurrences in a day.

For each group **ddmmyy**,

count number of records

if M14 = 10 or 14 or 15 or 20 or 21 or 25 or 29 or 50-56 or 60-65 or 80-82 or 91 or 92 or 95-99

OR

M19 = 9,

set = **R**

if **R > 2,**

then,

put **ddmmyy** in list **good8**

Repeat as needed for the next group

PRECIPITATION - FREEZING PRECIPITATION (9)

Definition: Includes any type of liquid precipitation that is reported as freezing. Includes cases where some type of freezing precipitation was reported, either at the time of the observation or within the past hour. Includes at least two occurrences in a day.

For each group **ddmmyy,**

count number of records

if M14 = 56 or 57 or 66 or 67

OR

M19 = 7,

set = **R**

if **R** >**2,**

then,

put **ddmmyy** in list **good9**

Repeat as needed for the next group

TEMPERATURE - VERY HOT TEMPERATURES (10)

Definition: Includes days where maximum temperature >= 95F (yK) Get conversion to Kelvin

For each group **ddmmyy,**

determine maximum value for M21

set = **MAXV**

if **MAXV** >= 95F (yK) Get conversion to Kelvin

then,

put **ddmmyy** in list **good10**

Repeat as needed for the next group

TEMPERATURE - HOT TEMPERATURES (11) Get conversion to Kelvin

Definition: Includes days where maximum temperature >= 85F (yK) but < 95F (zK)

For each group **ddmmyy,**

determine maximum value for M21

set = **MAXV**

if **MAXV** >= 85F (yK) but < 95F (zK)

then,

put **ddmmyy** in list **good11**

Repeat as needed for the next group

TEMPERATURE - COLD TEMPERATURES (12)

Definition: Includes days where minimum temperature <= 32F (yK) but > 0F (zK) Get conversion to Kelvin

For each group **ddmmyy**,

Determine minimum value for M21

set = **MINV**

If **MINV** <= 32F (yK) but > 0F (zK)

then,

put **ddmmyy** in list **good12**

Repeat as needed for the next group

TEMPERATURE - SEVERE COLD TEMPERATURES (13)

Definition: Includes days where minimum temperature <= 0F (yK) Get conversion to Kelvin

For each group **ddmmyy**,

Determine maximum value for M21

set = **MINV**

If **MINV** <= 0F (yK)

then,

put **ddmmyy** in list **good13**

Repeat as needed for the next group

TEMPERATURE - ABOVE AVERAGE TEMPERATURES (14) Get conversion to Kelvin

Definition: Includes days where average temperature > 5F (yK) above the average temperature for the period of interest.

Compute average value for M21 for all records in period of interest,

set value = **A**

For each group **ddmmyy**,

compute average value for M21,

set value = **AD**

if **AD** >= **(A + 50)**

then,

put **ddmmyy** in list **good14**

Repeat as needed for the next group

TEMPERATURE - AVERAGE TEMPERATURES (15)

Definition: Includes days where average temperature = +/- 5F (yK) of the average temperature for the period of interest. Get conversion to Kelvin

Compute average value for M21 for all records in period of interest,

set value = **A**

For each group **ddmmyy,**

Compute average value for M21,

Set value = **AD**

If **(A-50) <= AD >= (A + 50)**

then,

put **ddmmyy** in list **good15**

Repeat as needed for the next group

TEMPERATURE - BELOW AVERAGE TEMPERATURES (16)

Definition: Includes days where average temperature > 5F (yK) above the average temperature for the period of interest. Get conversion to Kelvin

Compute average value for M21 for all records in period of interest,

set value = **A**

For each group **ddmmyy,**

compute average value for M21,

Set value = **AD**

If **AD <= (A - 50)**

then,

put **ddmmyy** in list **good16**

RESTRICTED VISIBILITY - LOW VISIBILITY (17)

Definition: Includes days where average visibility <= 3 miles for > half the day for any restriction.

For each group **ddmmyy,**

count number of records,

set = **d**

count number of records

if M12 <= 4800

set = **R**

if **R** >= **0.5d**,

then,

put **ddmmyy** in list **good17**

Repeat as needed for the next group

RESTRICTED VISIBILITY - LOW VISIBILITY (18)

Definition: Includes days where average visibility <= 1.0 miles for > half the day for any restriction.

For each group **ddmmyy**,

count number of records,

set = **d**

count number of records

if M12 <= 1600

set = **R**

if **R** >= **0.5d**,

then,

put **ddmmyy** in list **good18**

Repeat as needed for the next group

RESTRICTED VISIBILITY - EXTREMELY LOW VISIBILITY (19)

Definition: Includes days where average visibility <= 0.5 miles for > half the day for any restriction.

For each group **ddmmyy**,

count number of records,

set = **d**

count number of records

if M12 <= 0800

set = **R**

if **R** >= **0.5d**,

then,

put **ddmmyy** in list **good19**

Repeat as needed for the next group

PERIODS - FOG (20)

Definition: Includes days where for >= 3 consecutive hours for >= 2 consecutive days fog is reported at near the same time each day.

Assign consecutive numbers to each group

Check records to see if M14 = 11 or 12 or 28 or 40-49 for >= 2 consecutive hours

OR

if M19 = 4

Identify hours where conditions are met in list **timexxx** (where xxx is the group's consecutive number)

Check next group in consecutive order and repeat

Check records to see if M14 = 11 or 12 or 28 or 40-49 for >= 2 consecutive hours

OR

if M19 = 4

Identify hours where conditions are met in list ***timexxx*** *(where xxx is the group's consecutive number)*

Continue checking until for and time don't match

Repeat process until all groups have been checked.

Then compare all **timexxx** lists to see if >= 1 value in each consecutive **timexxx** list is the same

then group put the **ddmmyy** groups used to build the consecutive **timexxx** lists into a single group called **consecfogxx**

then,

put **consecfogxx** in list **good20**

PERIODS - RAIN (21)

Definition: Includes days where for >= 3 consecutive hours rain is reported.

For each group **ddmmyy,**

count number of **consecutive records**

if M14 = 10 or 14 or 15 or 20 or 21 or 25 or 29 or 50-56 or 60-65 or 80-82 or 91 or 92 or 95-99

OR

M19 = 4-6 or 8 or 9,

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good21**

Repeat as needed for the next group

PERIODS - SNOW (22)

Definition: Includes days where for >= 3 consecutive hours snow is reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 22 or 23 or 25 or 70-79 or 83-90 or 93 or 94

OR

M19 = 7 or 8,

set = **N**

if **N** >= 2

then,

list **ddmmyy** in list **good22**

Repeat as needed for the next group

PERIODS - WIND (23)

Definition: Includes days where for >= 3 consecutive hours wind is 5 knots or more > the average is reported.

Compute average value for M02 for all records in period of interest,

set value = **A**

For each group **ddmmyy**,

Compute average value for M02,

Set value = **AD**

If **AD** >= **(A + 10)** Check conversion of knots to meters per second

then,

put **ddmmyy** in list **good23**

Repeat as needed for the next group

PERIODS - LOW CEILINGS AND RAIN (24)

Definition: Includes days where for >= 3 consecutive hours low ceilings and rain are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 10 or 14 or 15 or 20 or 21 or 25 or 29 or 50-56 or 60-65 or 80-82 or 91 or 92 or 95-99

OR

M19 = 4-6 or 8 or 9,

and

if M06 = 07, 08, 09, or 10

<u>and</u>

M04 <= 33 or >= 90 and <= 95,

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good24**

Repeat as needed for the next group

PERIODS - LOW CEILINGS AND SNOW (25)

Definition: Includes days where for >= 3 consecutive hours low ceilings and snow are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 22 or 23 or 25 or 70-79 or 83-90 or 93 or 94

OR

M19 = 7 or 8,

and

if M06 = 07, 08, 09, or 10

<u>and</u>

M04 <= 33 or >= 90 and <= 95,

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good25**

Repeat as needed for the next group

PERIODS - LOW CEILINGS AND FOG (26)

Definition: Includes days where for >= 3 consecutive hours low ceilings and fog are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 11 or 12 or 28 or 40-49

OR if M19 = 4

and

if M06 = 07, 08, 09, or 10

<u>and</u>

M04 <= 33 or >= 90 and <= 95,

set = **N**

if **N** >= 2

then,

list **ddmmyy** in list **good26**

Repeat as needed for the next group

PERIODS - VERY LOW CEILINGS AND RAIN (27)

Definition: Includes days where for >= 3 consecutive hours very low ceilings and rain are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 10 or 14 or 15 or 20 or 21 or 25 or 29 or 50-56 or 60-65 or 80-82 or 91 or 92 or 95-99

OR

M19 = 4-6 or 8 or 9,

and

if M06 = 07, 08, 09, or 10

<u>and</u>

M04 <= 11 or >= 90 and <= 93,

set = **N**

if **N** >= 2

then,

list **ddmmyy** in list **good27**

Repeat as needed for the next group

PERIODS - VERY LOW CEILINGS AND SNOW (28)

Definition: Includes days where for >= 3 consecutive hours very low ceilings and snow are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 22 or 23 or 25 or 70-79 or 83-90 or 93 or 94

OR

M19 = 7 or 8,

and

if M06 = 07, 08, 09, or 10

and

M04 <= 11 or >= 90 and <= 93,

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good28**

Repeat as needed for the next group

PERIODS - VERY LOW CEILINGS AND FOG (29)

Definition: Includes days where for >= 3 consecutive hours very low ceilings and fog are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 11 or 12 or 28 or 40-49

OR

if M19 = 4

and

if M06 = 07, 08, 09, or 10

and

M04 <= 11 or >= 90 and <= 93,

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good29**

Repeat as needed for the next group

PERIODS - LOW CEILINGS, LOW VISIBILITY AND RAIN (30)

Definition: Includes days where for >= 3 consecutive hours low ceilings, low visibility, and rain are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 10 or 14 or 15 or 20 or 21 or 25 or 29 or 50-56 or 60-65 or 80-82 or 91 or 92 or 95-99

OR

M19 = 4-6 or 8 or 9,

and

if M06 = 07, 08, 09, or 10

and

M04 <= 33 or >= 90 and <= 95,

and

if M12 <= 1600

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good30**

Repeat as needed for the next group

PERIODS - LOW CEILINGS. LOW VISIBILITY, AND SNOW (31)

Definition: Includes days where for >= 3 consecutive hours low ceilings, low visibility, and snow are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 22 or 23 or 25 or 70-79 or 83-90 or 93 or 94

OR

M19 = 7 or 8,

and

if M06 = 07, 08, 09, or 10

and

M04 <= 33 or >= 90 and <= 95,

and

if M12 <= 1600,

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good31**

Repeat as needed for the next group

PERIODS - LOW CEILINGS, LOW VISIBILITY, AND FOG (32)

Definition: Includes days where for >= 3 consecutive hours low ceilings, low visibility, and fog are reported.

For each group **ddmmyy**,

count number of **consecutive records**

if M14 = 11 or 12 or 28 or 40-49

OR if M19 = 4

and

if M06 = 07, 08, 09, or 10

and

M04 <= 33 or >= 90 and <= 95,

and

if M12 <= 1600,

set = **N**

if N >= 2

then,

list **ddmmyy** in list **good32**

Repeat as needed for the next group